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2       1. An apparatus for providing chemical and biological detection of molecules  
3 adsorbed on an organic self-assembled surface, comprising:

4             a gate contact;

5             a gate insulator attached to the gate contact;

6             a source contact attached to the gate insulator;

7             a drain contact attached to the gate insulator; and;

8             a semiconductor layer extending between the source and drain comprising

9             an organic monolayer of molecules, each molecule comprising a sensing end

10           group, a conjugated segment covalently bonded to the sensing end group, and an

11           attaching end group covalently bonded to the conjugated segment and attached to

12           the gate insulator.

13       2. The apparatus as recited in claim 1, wherein the sensing end group is  
14 selected from the group consisting of halides, nitriles, amines, amides, and ketones.

15       3. The apparatus as recited in claim 1, wherein the attaching end group is  
16 selected from the group consisting of trichlorosilyl groups, amines, and carboxylic acid  
17 groups.

18       4. The apparatus as recited in claim 1, wherein the conjugated segment is  
19 selected from the group consisting of phenyl-acetylene and phenylene-vinylene.

1       5. The apparatus as recited in claim 1, configured such that adsorbed  
2 molecules can be selectively removed from the sensing end group by heating the organic  
3 self-assembled monolayer and driving off adsorbed species of vapor molecules.

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5       6. The apparatus as recited in claim 1, wherein the sensing end group  
6 generates an atomically sharp interface for differentiating between vapor molecules.

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8       7. The apparatus as recited in claim 1, wherein a substance is detected when  
9 the sensing end group adsorbs a threshold amount of a desired vapor molecule.

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2       8. An organic self-assembled transistor fabricated on a silicon substrate, the  
3 transistor comprising:

4             a gate contact;

5             a gate insulator attached to the gate contact;

6             a source contact attached to the gate insulator;

7             a drain contact attached to the gate insulator; and

8             a semiconductor layer between the source and drain, the layer comprising

9             an organic self-assembled monolayer of molecules.

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11        9. The transistor as recited in claim 8, wherein the organic self-assembled  
12 monolayer comprises a pentacene film.

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14        10. The transistor as recited in claim 9, wherein the pentacene film is about  
15 10nm thick.

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17        11. The transistor as recited in claim 8, wherein each molecule of the organic  
18 self-assembled monolayer comprises:

19             a sensing end group;

20             a conjugated segment covalently bonded to the sensing end group; and

21             an attaching end group covalently bonded to the conjugated segment and

22             attached to the gate insulator.

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24        12. The transistor as recited in claim 11, wherein the sensing end group can be  
changed to control the chemical properties of the sensing surface.

1           13. The transistor as recited in claim 11, wherein the organic self-assembled  
2 monolayer generates an atomically sharp interface for differentiating between vapor  
3 molecules via the sensing end group.

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5           14. The transistor as recited in claim 11, wherein the sensing end group is  
6 selected from the group consisting of halides, nitriles, amines, amides, and ketones.

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8           15. The transistor as recited in claim 11, wherein the conjugated segment is  
9 selected from the group consisting of phenyl-acetylene and phenylene-vinylene.

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11          16. The transistor as recited in claim 11, wherein the attaching end group is  
12 selected from the group consisting of trichlorosilyl, amines, and carboxylic acid groups.

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14          17. The transistor as recited in claim 11, wherein charge carrier density of the  
15 sensing end group changes according to the adsorption of vapor molecules.

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17          18. The transistor as recited in claim 11, wherein charge mobility of the  
18 sensing end group changes according to the adsorption of vapor molecules.

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20          19. The transistor as recited in claim 11, wherein current pulses heat the  
21 organic self-assembled monolayer so that adsorbed species of vapor molecules are  
22 removed from the sensing end group.

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24          20. The transistor as recited in claim 19, wherein the energy required to heat 3  
x 10<sup>-13</sup> cm<sup>3</sup> of the organic self-assembled monolayer is about 15 pJ.

1           21. The transistor as recited in claim 11, wherein the sensing end group may  
2 be removed and replaced without removing the conjugated segment or the attaching end  
3 group.

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2        22. A process of making an organic self-assembled transistor on a silicon  
3 substrate, the process comprising the steps of:

4                  high-temperature processing of the silicon to generate a substrate, a gate, a  
5 gate insulator, a source and a drain for the transistor; and

6                  depositing an active organic monolayer between the source and drain, the  
7 active monolayer attaching to the gate insulator via an attaching end group.

8        23. The process as recited in claim 22, wherein the active organic monolayer  
9 is deposited using micro-contact printing.

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11       24. The process as recited in claim 23, wherein the depth of the active organic  
12 monolayer is between about 3nm and about 10nm.

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14       25. The process as recited in claim 22, wherein the depth of the active organic  
15 monolayer is less than about 10nm.

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17       26. The process as recited in claim 22, wherein differential response  
18 characteristics of the active organic monolayer vary according to concentration levels of  
adsorbents on the surface of the monolayer.

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2        27. The process as recited in claim 22, wherein the active organic monolayer  
3 comprises a conjugated segment covalently bonded to said attaching end group and a  
4 sensing end group covalently bonded to said conjugated segment.

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6        28. The process as recited in claim 27, wherein the sensing end group can be  
7 changed to control the chemical properties of the sensing surface.

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9        29. The process as recited in claim 27, wherein said attaching end group is  
10 chemically bonded to the gate insulator.

11        30. The process as recited in claim 22, wherein the substrate is a silicon  
12 substrate and wherein the contacts are metals.

13        31. The process as recited in claim 30, wherein the contacts are selected from  
14 the group consisting of gold, aluminum, silver, platinum, copper, lithium, calcium, and  
15 combinations thereof.

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17        32. The process as recited in claim 22, wherein the gate insulator is a high  
18 dielectric constant oxide.

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20        33. The process as recited in claim 32, wherein the gate insulator is yttria  
21 stabilized zirconia.

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23        34. The process as recited in claim 32, wherein a dielectric constant of the  
24 gate insulator is greater than about 4.

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35. A chemical and biological sensor array system, the system comprising:  
an array of organic self-assembled single transistor sensors;  
a processing module; and  
silicon circuitry connecting the array to the processing module.

36. The system as recited in claim 35, the array of organic self-assembled transistors further comprising at least two organic self-assembled transistor sensors calibrated to detect different vapor molecules.

37. The system as recited in claim 36, wherein the processing module monitors differential responses from organic self-assembled transistors in the array, the processing module detecting changes in the differential responses associated with the adsorption of vapor molecule species.

38. The system as recited in claim 35, wherein the silicon circuitry configured such that the transistor sensors can be packaged as an integrated circuit where the organic self-assembled transistor sensors are exposed to the testing atmosphere.

39. The system as recited in claim 35, wherein the organic self-assembled single transistor sensor comprises:  
a transistor including a source, a drain, a gate, and a gate insulator; and  
a semiconductor self-assembled monolayer channel bonded to the gate insulator between the source and drain of the transistor, the monolayer changing charge mobility and charge density upon adsorption of vapor molecules.

1           40. The system as recited in claim 39, wherein the monolayer comprises  
2 individual organic monolayer molecules for self-assembly covalently bonded to other  
3 surrounding organic monolayer molecules.

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5           41. The system as recited in claim 40, wherein the monolayer provides  
6 maximum response when each of the molecules adsorbs a desired vapor molecule.

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8           42. The system as recited in claim 39, wherein the monolayer provides  
9 measurable transistor response changes to low concentrations of less than  $10^{-16}$  moles of  
10 analyte molecules.

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12          43. The system as recited in claim 39, wherein the monolayer provides  
13 maximum response in the presence of analyte molecules even at low concentrations of  
14 about  $10^{-16}$  moles.

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